Seeing the Big Picture: An Application of Hand-held Technologies in Managing Environmental Data

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ABSTRACT

The Automated Resource Management System (ARMS™) automates collection, synchronization, analysis, reporting, and archiving of georeferenced data in a variety of applications not attainable conventionally. ARMS™ technology enables an innovative life-cycle management process that significantly improves data collection, reliability, and integration capabilities as well as facilitates stewardship, compliance, and sustainability requirements. It provides an innovative, cost-effective and time-efficient, programmatic approach to understanding and solving environmental management issues. Applications may include: environmental, safety, security, military, educational, emergency management, land use, fish and wildlife management, construction and maintenance of highways and waterways, mining, exploration, manufacturing, recreational management, urban restoration, and cultural resource management.

At first glance the inclusion of an environmental paper in these proceedings may seem out of place. However, if you look at the big picture, the fundamental issue is the same—life-cycle resource management. Whether you are dealing with the built environment and infrastructure, or the natural environment and cultural landscape, the initial basic concerns are the same—knowing the physical location of each resource, as well as its geospatial relationship to others on the landscape/facility. Once this baseline order is established, then the problem solving and management issues can then be addressed. Life-cycle management requires planning, data collection, and analysis in order to anticipate, identify, and solve problems. The objective is to develop an intuitive, business management practice, integrating logic-based technologies that will provide the decisionmaker the pertinent information to improve efficacy. Given that, a programmatic management model, that identifies the problems and ranks their priority and tracks their resolution, can then be implemented for the duration of the project/facility, in a proactive, efficient process.

This paper demonstrates a life-cycle approach to automating and improving cultural resource management. The ideas and practices presented here can be used as a model to develop similar approaches to improve other environmental programs, and conceptually, to facility management and other arenas.

DoD installations and Federal land-holding Agencies are tasked with complying with a variety of environmental legislations (e.g., NEPA, NHPA, ESA, CWA, etc.). These laws are designed to inventory, manage, and conserve natural and cultural resources. Environmental sustainability and land-use requirements at installations are often difficult to achieve due to competing needs and restrictions. Complex integrated programs are essential to meet these mission objectives. Central to this issue is the need for accurate and consistent data. Current methods and techniques used to collect data are labor intensive, time consuming and costly. Given the common, less-than-ideal field circumstances, important information can be missed or recorded improperly. Factors such as the competence of the technician,

inconsistent data collection practices between contractors, and the redundancy and errors associated with manual recordation/transcription techniques, all affect the quality and reliability of the data.

While existing commercial off-the-shelf tools are available for natural and cultural resources data collection needs, they are typically single, stand-alone technologies that have limited functionality and integration capabilities. With increased emphasis to implement and maintain sustainable environmental practices, innovative technologies and applications must be developed to meet mission requirements. The solution is a new specialized technology that addresses environmental issues programmatically—an Automated Resource Management System (ARMS™).

ARMS™ is an innovative management process that can be used to study and resolve a wide variety of environmental issues. It consists of integrated digital technologies and specialized software applications that will significantly improve the methods used to collect, store, and analyze environmental data throughout the life-cycle process.

ARMS™ can be used for all types of routine and complex, natural and cultural resources investigations (e.g., inventory, evaluation, mitigation), including development, sustainability, and rehabilitation efforts. It can serve as a powerful decision-making tool to facilitate both short- and long-term management requirements (e.g., monitoring/change detection of historic properties, invasive species encroachment, etc.). And, it inherently has the ability to track and measure field data collection practices, which can then be analyzed to implement methodological improvements.

The basic components of ARMS™ are:

- An in-field application consisting of:
  - Two or more small, ruggedized, sun-shielded, portable computers as the field units for manually recording and integrating data from instruments and other sources (e.g., specialized data entry forms, aerial photography, digital map coverages)
  - A robust tablet PC to consolidate data from two or more field units and to run other applications.
- High-resolution, digital instruments (i.e., camera, global positioning system, compass, clock, and bar code labeler) to collect data.
- The ability to collect, store, and synthesize different types of data to a common shared database:
  - Geographical Information System (GIS) data (compliant with FGDC and SDSFIE standards)
  - Global Positioning System (GPS) data
  - Manually entered data
  - Other associated media (e.g., video and audio).
- Data fusion software to interface and synchronize existing hardware functions and software applications.
- Wired, infrared and/or digital wireless communications devices that will:
  - Transmit and store data for remote uploading and downloading from the field units to the office unit
  - Print bar coded labels to track field specimens
- Additional peripherals may include: laser range finder, audio and video capabilities, inclinometer, altimeter, thermometer, barometer, geophysical instruments, etc.

Illustrations depicting the business processes, hardware configuration, and costs as well as portability of the ARMS™ in a field setting are included in Figures 1-3.

Embedded in the system is a fully functional GIS. The benefit of having geospatially referenced attribute data is that it expedites the resolution of critical environmental management issues. For critical land-use decisions, real-time wireless transmission of data and images are available—enabling the ARMS™ to serve as a virtual-desktop in the field.

The ARMS™ components are ergonomically designed for ease of setup and use. The flexibility of the system is that it allows the user to select and pre-load software applications and configure hardware tailored for the specific type and level of investigation (e.g., wetlands delineation, cultural resources inventory, habitat assessment). Project data and GIS coverages can also be pre-loaded prior to fieldwork (e.g., survey transects and sample plot coordinates). This will ensure accuracy and efficiency and cut down on unanticipated delays. The handheld PCs contain interactive electronic databases that can either be populated automatically, via integrated elements and/or from hardware attached to expansion ports. All databases are relational and denormalized.

For each specific environmental application the ARMS™ program contains a series of digital forms that are organized in a logical, progressive manner. The application guides the user through the various required or recommended steps, or displays alternative choices for the user. Menus consist of a series of drop-down lists with options and/or radio buttons. For each program, links are provided for off-line access to pre-loaded, digital reference guides to aid the user while in the field (e.g., soil descriptions, artifact typologies, plant references, architectural elements, etc.). Each form is versatile and can be customized for unique situations. Included on every form is a space to manually enter data for circumstances not anticipated. To ensure accuracy and efficiency, each form must be filled out completely before the program advances to the next form.

A key feature of this field unit is a single pushbutton that activates a number of automated and time-saving measurements at once—a "snapshot" with a time stamp that is simultaneously applied to the entire data set. The operator aims the unit at the target and presses the record button, which captures a digital image, obtains GPS positioning, azimuth, elevation, and other metric attributes, and then stores the data in a database with a time stamp and unique I.D. attached. Because the data is collected digitally it allows for immediate verification of the quality and usefulness of the data. Finally, the collected data (i.e., forms, GPS, GIS shape files, video and audio images) are downloaded from the field unit to the tablet PC. This is done in a one-step process using either an infrared, wired, or radio frequency connection, or a serial or USB connection, between the field units and the tablet PC. This in-field computer, which has more powerful software tools, is then used for additional processing and analysis. An efficient feature of ARMS™ is an automated, pre-programmed function on the tablet PC that is structured to query the database in order to generate customized reports at the end of the project (e.g., archeological site forms, plant and/or animal inventories, etc.), thereby reducing transcription redundancy.

All field specimens (e.g., artifacts, soils, minerals, plants, etc.) are collected, bagged, and affixed with a unique bar code label in the field. The labels are printed to include text descriptions (e.g., project I.D. and provenience data). The benefit of bar coding is that it facilitates automated inventory, tracking, and retrieval of the specimen throughout the life cycle of the project, and to improve curation and future research requirements.

ARMS™ technology significantly improves data collection, reliability, and integration. ARMS™ technology, coupled with an enterprise level, SDSFIE compliant data structure such as a relational database (i.e., Oracle or SQL server), and/or a GIS database (i.e., ArcGIS, MapObjects) is flexible and

can be used for a variety of different environmental studies. These other fields may include, but certainly are not limited to: safety, security, military, educational, emergency management, land use, fish and wildlife management, construction and maintenance of highways and waterways, mining, exploration, manufacturing, recreational management, and urban restoration.

Finally, the ability to share accurate, georeferenced data across multiple platforms while addressing different environmental and management requirements will significantly improve real-time decision-making capabilities. The ARMS™ technology demonstrates an innovative, programmatic approach to understanding, anticipating, and solving environmental management and sustainability issues throughout the life-cycle of the project.

ARMS™ was conceived and developed by the U. S. Army Corps of Engineers, Engineer Research Development Center, Construction Engineering Research Laboratory, Champaign, IL. The prototype and computer code were produced by Coonewah Consulting, Inc., Jackson, MS, under contract to Geo-Marine Inc., Plano TX (DACA42-02-D-0012-0001). The total cost for development was $93,103.00. Of that figure, $13,228.04 was used to purchase the hardware ($5,084.02 x 2) and software ($3,060). The ARMS™ patent application was filed with the US Patent Office on 8 December 2003 (COE-564, serial number 10/729,269).

For additional information, please contact:

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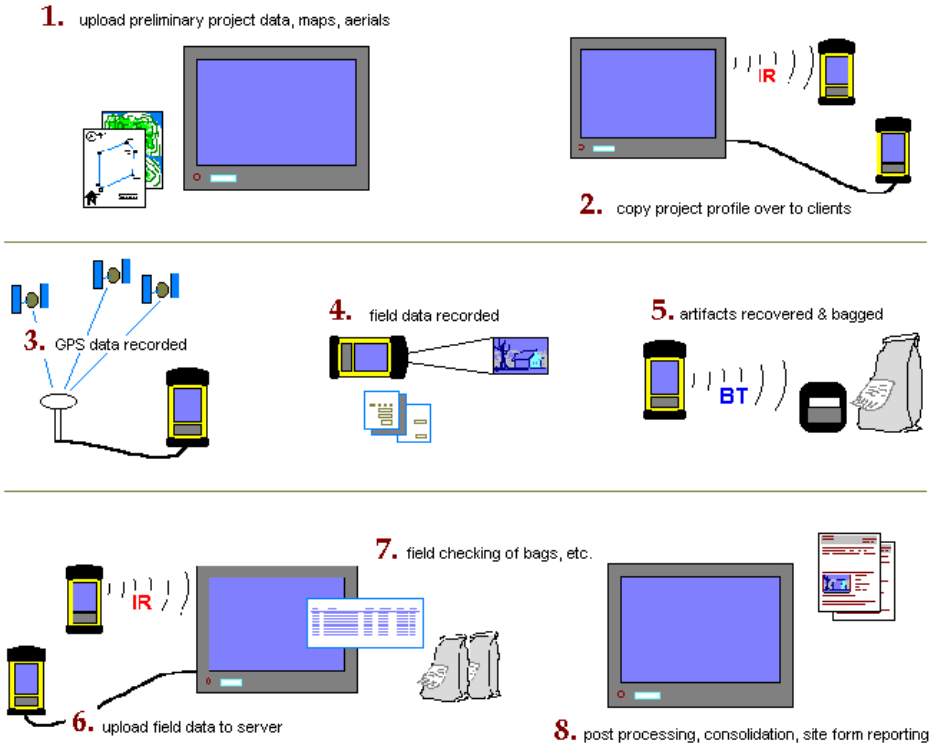
Figure 1. ARMS™ Business Management Process Overview

The diagram below proposes data flow with the hardware and software recommended.



- Step 1: Maps, aerial photographs, and other geo-referenced data are uploaded into a new project using SoloOffice.
- Step 2: Base maps and project information is compiled and copied over as a whole to the field devices running SoloField.
- Steps 3 - 5: Field devices log GPS coordinates, elevation, and prompt the field user to enter data regarding the field survey that is being conducted at that station. This includes recordation of form data as well as any notations, photographs, video, or dictation that needs to be recorded. If material is recovered, a bag number with relevant station data is generated and transmitted to print a label for the collection bag.
- Step 6: Data are uploaded to the tablet PC where they are consolidated and check lists are generated.
- Step 7: After data from multiple field units have been consolidated, a series of checks ensure that all bags/specimens recorded have been collected. In addition, the consolidated GIS data facilitates in-field spot-checking for anomalies prior to leaving the field.
- Step 8: The in-field tablet PC is not the final resting place for these data, so the consolidated files may either be uploaded to a centralized server or backed up on tape or CD.

Figure 2. ARMS™ Prototype Hardware Specifications:

The recommended equipment to be employed for one field unit includes:

1) TDS Recon Handheld PC

Ruggedized:	Yes
Processor:	400 MHz Intel Xscale
Memory:	64 SDRAM + 128 MB Flash storage
Battery Life:	15 hours
Dimensions:	6.5 x 3.8 x 1.8 inches
Weight:	490 grams
IP Rating:	6 . 7
Price:	$3,100.00

2) Garmin N17 GPS Receiver

Ruggedized:	Yes
Communication:	Serial cable
Accuracy:	3 meter
Battery:	12v NiMH, 8 hours
Weight:	373 grams
Price:	$900.00

3) FlyCAM 1.3 Megapixel CompactFlash Camera

Ruggedized:	No
Communication:	CF Type II
Resolution:	still 1280 x 1024, video 240 x 3320 @30 fps
Price:	$104.53

4) SimpleTech 1 Gig CompactFlash Card

Ruggedized:	No
Communication:	CF Type II
Price:	$288.49

5) Cognitive Code Ranger RD23 Direct Thermal Portable Printer

Ruggedized:	Yes
Communication:	RJ45 Serial, Bluetooth/WiFi optional
Resolution:	203 dots per inch
Battery Life:	8 hours
Weight:	680 grams
Price:	$691.00

Software Recommended

Solo Office	$1,000.00
Solo Field (licensed per field unit)	$1,000.00
WinCESoft CF Camera Driver (per field unit)	$30.00

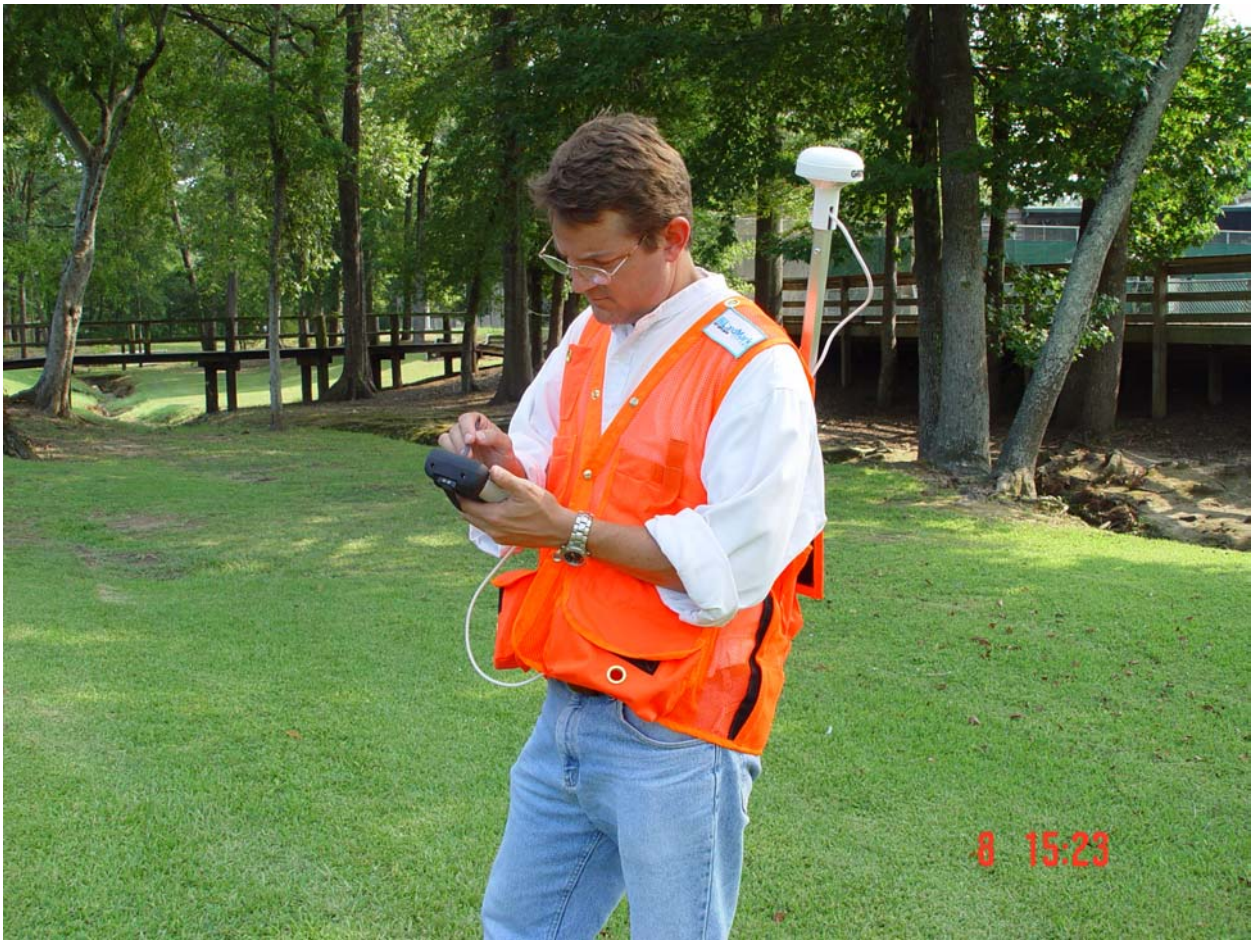


Figure 3. ARMS™ Prototype in Survey Mode.